

Universal Synchrony Music

Telematic Music Composition for Twelve Performers and Conductor

A Dissertation Presented

by

Sarah Rose Weaver

to

The Graduate School

in Partial Fulfillment of the

Requirements

for the Degree of

Doctor of Philosophy

in

Music

(Composition)

Stony Brook University

May 2018

Stony Brook University
The Graduate School

Sarah Weaver

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Doctor of Philosophy degree, hereby recommend
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Abstract of the Dissertation

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Universal Synchrony Music (USM) is an electroacoustic telematic composition by Sarah Weaver—in collaboration with the NASA Kepler/K2 Mission and NASA ArtSpace—exploring musical, technological, and metaphorical realizations of synchrony. Synchrony is defined as perception of alignment of distributed time and space components. Telematic music is live performance via the internet by musicians in different geographic locations. Sonification of data on stars and planets in the Kepler field 1000-3000 light years away is utilized for presence across distance, inherent expressions of multiplanetary habitable systems, and interactions for synchrony.

Concepts explored in USM include: interaction and harmonization with cosmic sounds; creating perception of synchrony across local and extreme distances; Kepler/K2 Missions' search for habitability as a search for synchrony; and cultural and human levels of synchrony. Data elements that have been sonified for USM are star and planet light curves, phase curves, surface gravity, insolation, magnitude, radius, temperature, celestial coordinates, period, transit depth, transit duration, solar planet ratio, distance from Earth, and orbital alignments with Earth. Musical concepts are realized through elements such as resonance, timbral synthesis, alignment of intervals and harmonies, orbital approach to time and contour, and spatialization. Surround sound enables the expansive experience of spatialized sonification of data, such as orbiting, constellations, and being inside of a habitable planetary system. The resultant synchrony of the piece is realized through synthesis of presence with these deep space systems, representations and intuitive transmissions of inherent synchronies, along with metaphorical realizations.

Kepler/K2 Mission Data Collaborators: Jon Jenkins - Analysis Lead for the NASA Kepler/k2 Mission, Senior Research Scientist, SETI Institute, NASA Ames Research Center. Professors William Welsh, Jerome Orosz, and Donald Short, Astronomy Department, San Diego State University. Madeline Huberth, Center for Computer Research in Music and Acoustics, Stanford University. Daniel Fabrycky, Assistant Professor, Department of Astronomy and Astrophysics, University of Chicago.

Sonifications Collaborator: Doug Van Nort, DisPerSion Lab, York University

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List of Performance Notes

1) Locations and Instrumentation

Location 1: In Western Hemisphere

4 instrumentalists (Range: SATB), 1 percussionist (drumset or multiple percussion including toms and cymbals)

Location 2: In Eastern Hemisphere

4 instrumentalists (Range: SATB), 1 percussionist (drumset or multiple percussion including toms and cymbals)

Location 3: In any geographic location

1 piano, 1 electronics, 1 conductor

Locations perform together live via JackTrip audio conferencing software and Ultragrid video conferencing software on 1Gbps Internet bandwidth (or contemporary equivalent technology).

2) Narrative

Universal Synchrony Music (USM) is an electroacoustic telematic composition by Sarah Weaver—in collaboration with the NASA Kepler/K2 Mission and NASA ArtSpace—exploring musical, technological, and metaphorical realizations of synchrony. Synchrony is defined as perception of alignment of distributed time and space components. Telematic music is live performance via the internet by musicians in different geographic locations. Sonification of data on stars and planets in the Kepler field 1000-3000 light years away is utilized for presence across distance, inherent expressions of multiplanetary habitable systems, and interactions for synchrony.

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3) Score Details

The score contains palettes of materials including music notation, text notation, graphic notation, gestures, structured improvisations, and sonifications. Perform the palettes in numerical sequence on cue by the conductor. Time length indications are approximate. The piece is composed with the expectation of latency between the locations. Perform the materials as written within the latency of the medium. All boxed text in the score is detailed in the performance notes.

4) Terms

Extensions (Palettes 3, 12): Improvisation that expands and intensifies the current material.

Attention Strategy (Palettes 2, 4, 5, 7, 9, 10, 13-15): Focus your attention on the given strategy and let this influence the improvisation. Attention strategy is a device from composer Pauline Oliveros.

5) Sonifications

Sonification 1 (Palette 1): File: “koi_orbiting”

The file contains data on the orbits of Kepler area habitable planets in multiplanetary systems. The T0 data point is where each habitable planet aligns with Earth during its orbit. Scale the timing of the orbits so that the density of T0 data points are close enough together to create multiplicities. Play a meditation chime electronic sound at the T0 data point of each habitable planet. Pitch is highest for planets with fastest orbits, lowest for slowest orbits, within range of pitch C1-C7.

Sonification 2 (Palette 2): File: “kepler1”

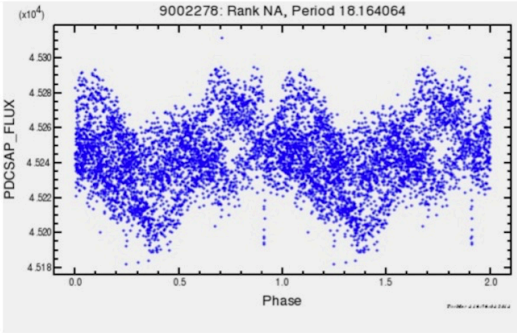
The file contains data on light curves of stars from multiplanetary systems with habitable zones. Play stars individually using spectral harmonics shaped by the light curves. Each star should be 3-5 seconds in length. Pause 5-10 seconds between each star. Highest fundamental pitches closest to earth, lowest fundamental pitches furthest away.

Sonification 3 (Palettes 4, 8): Files: “kepler1” “kepler 2” “kepler 3”

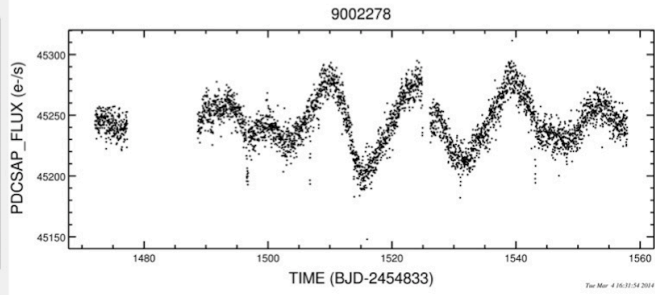
These files contain data on the stars of multiplanetary habitable systems. The three files are three Kepler areas in latitude sequence based on celestial coordinates. Play bright meditation chime electronic sound with harmonics for each star with sonified vibrato according to brightness. Perform with sonified time intervals between each star within range 30-90BPM to create constellations. Highest fundamental pitches closest to earth, lowest fundamental pitches furthest away.

Acoustic Instruments 1-4: Play these plots of Kepler 62 and 69 habitable planets as graphic notation.

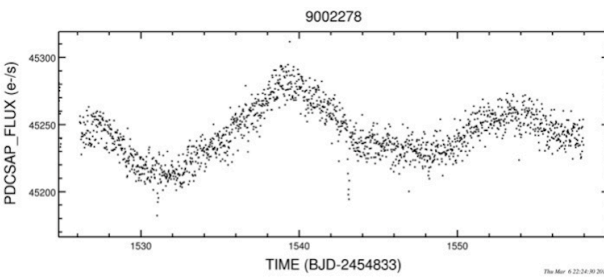
Kepler 62



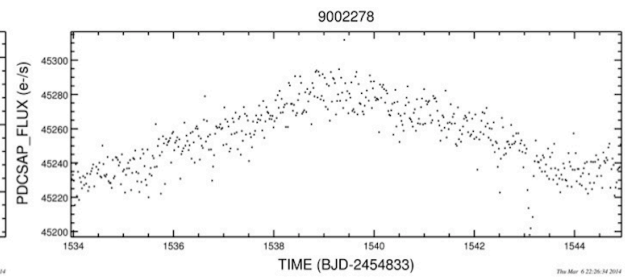
PHASE CURVE



LIGHT CURVE

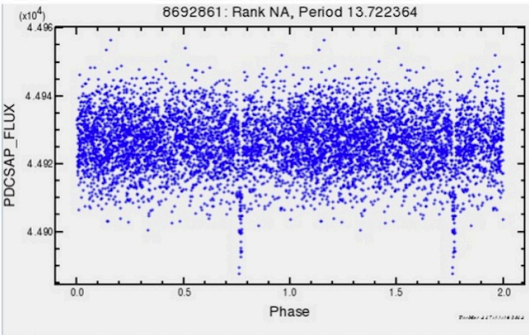


LIGHT CURVE ZOOM 1

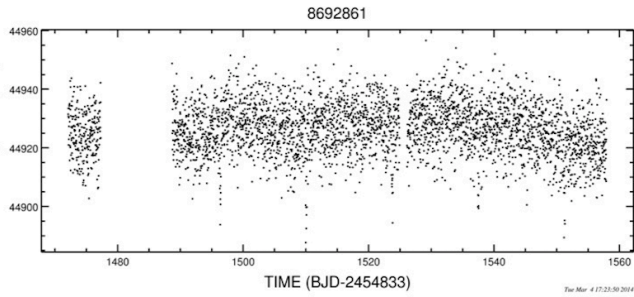


LIGHT CURVE ZOOM 2

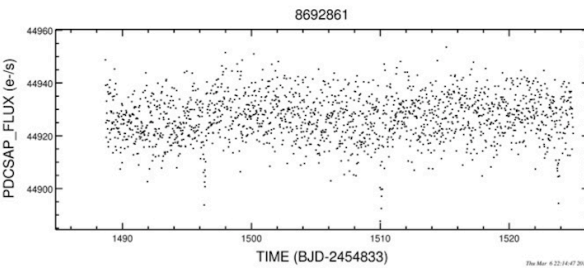
Kepler 69



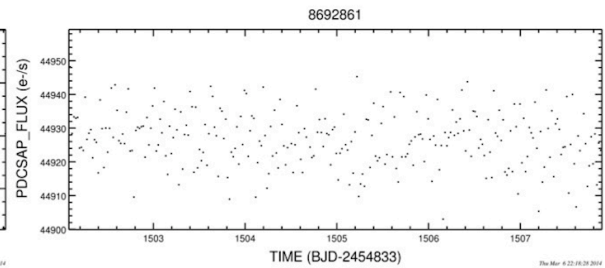
PHASE CURVE



LIGHT CURVE



LIGHT CURVE ZOOM 1



LIGHT CURVE ZOOM 2

Sonification 4 (Palettes 11-15)

Files: "kepler47 orbits", "Table1_Kepler47d", "Kep47c-insolation", "Kep47d-insolation"

These are data files of the Kepler 47 binary star system, containing a habitable zone. There are five objects – two stars and three planets. Sonify the orbit of this system in a similar way to sonification 1, playing a chime at a T0 data point. Use the brighter chime with vibrato for the two stars, the non-vibrato chime for the three planets. Add the insolation sonification as brighter timbre and vibrato to the planets when they are insolated. Using the system parameters table, sonify the brightness of the stars and magnitude of the planets as volume and length of the object. The length per object is between a half second and two seconds. Sonify the pitches of the system within a major 10th, with option to transpose in sequence.

Max Patches for Reading and Filtering Data

Links to Max patch files from sonifications collaborator Doug Van Nort are included in appendix for the electronic performer(s). There are versions for data that includes scientific notation and data that is text only. Note the data should be formatted as tab delimited for these patches. The patches can be utilized for the data and connected to individual performance software and hardware.

6) Lexicon for Conductor Gestures

The gestures are a combination of Soundpainting originated by Walter Thompson, traditional conducting, and original gestures by Sarah Weaver. They can be utilized at any time throughout the piece. At the discretion of the conductor, gestures can be utilized in **Split Body**: musicians on the left side of the conductor follow the left side of the body, musicians on the right side of the conductor follow the right side of the body. Gestures can also be utilized in **Location Body**: establish three areas in front of the body to indicate the three geographic locations of the musicians, musicians respond to gestures given to their location.

Palette

Meaning: Number of section (corresponds with rehearsal numbers).

Gesture: Fist of right hand in palm of left hand with fingertips facing up. Then a number is shown in the right hand to indicate section.

Cue

Meaning: Enter, Exit.

Gesture: Enter - slightly cupped hand, palm up, fingers pointed towards the performer.

Exit - circular motion of the hand from palm up to palm down while closing the fingers.

Group

Meaning: Indicates next gesture is for the Group only.. Group 1 = Location 1, Group 2 = Location 2, Group 3 = Location 3.

Gesture: Two fists facing body, one on top of the other, followed by a number.

Volume Fader

Meaning: Level of dynamics.

Gesture: A 'v' is formed with the first two fingers in the hand. Up is loud, down is soft.

Density Fader

Meaning: Amount of silence between sounds.

Gesture: Fingers facing away from body, palms facing each other, hands move horizontally. Hands close together indicates high density, further apart indicates low density.

Shapeline - Pulseline

Meaning: Musically respond to the shapes and pulses shown by the conductor.

Gesture: Shown with the arms and full body. The neutral position is arms at the sides of the body.

Dimension Point

Meaning: Improvise another layer to the current material.

Gesture: One finger pointing to a musician.

Pitch Complex Fader: Long Tone, Drone, Gliss, Vibrato, Pulsate, Hits, Pointillism, Resonance, Timbre, Harmonics

Meaning: Complex Faders contain multiple gestures within one overall fader.

Gesture: Pitch Complex Fader is initiated by one or two hands with palm down, six inches to the side of the body, fingers pointing towards the body. Location on vertical plane indicates pitch range high to low relative to instrument. Use any of the following gestures:

Long Tone

Meaning: Sustained pitch.

Gesture: Flat hand, palm down.

Drone

Meaning: Long tone undulations centered in the pitch level indicated.

Gesture: Flat hand, palm down, circular motion.

Gliss

Meaning: Glide between long tones in range shown.

Gesture: Flat hand, palm down, move vertically.

Vibrato

Meaning: Oscillation of micro pitch variations.

Gesture: Flat hand, palm down, moving up and down quickly.

Pulsate

Meaning: Accent the pitch as shown.

Gesture: Flat hand, palm down, moving up and down in steady pulse.

Hits

Meaning: One sound on cue within pitch range shown.

Gesture: Two hands, fingers facing ensemble, first three fingers make a point. Wrist movement gives hit timing in the fingers.

Pointillism

Meaning: Staccato sounds in high density.

Gesture: Fist.

Resonance

Meaning: Increase fullness of sound.

Gesture: Curved hand, palm down

Timbre

Meaning: Change the quality of the sound.

Gesture: Curved hand, palm facing body

Harmonics

Meaning: Harmonics and multiphonics.

Gesture: Fingers spread, palm facing body.

Space Complex Fader: Hold, Extend, Multiply, Constellate, Loop, Spectralize, Gravitate, Merge, Synchronize

Meaning: Complex Faders contain multiple gestures within one overall fader.

Gesture: Space Complex Fader is initiated by left hand with palm down, fingers pointing away from body, arm extended. Then the right hand shows any of the following gestures:

Hold

Meaning: Play a long tone on the current pitch for the duration of the gesture.

Gesture: Right palm placed on top of left palm.

Extend

Meaning: Play an elaboration based on the current material.

Gesture: Right palm placed palm up on top of left palm.

Multiply

Meaning: Based on current sounds in the ensemble, play an axis of rhythms that vary yet closely intersect. This can optionally be applied to pitch and timbre as well.

Gesture: Right fingers spread facing upwards, palm facing body.

Constellate

Meaning: Based on current sounds in the ensemble, play a sequence of 4-7 pitches that include steps, leaps, and variance of length between each sound within 30-90BPM. Utilize vibrato on each pitch.

Gesture: Right fingers spread facing upwards, palm facing away from body.

Loop

Meaning: Loop the current material for the duration of the gesture according to the loop length shown.

Gesture: Right palm facing down, hovering above left palm. Higher above left palm is longer loop, lower is shorter loop.

Spectralize

Meaning: Create a texture of discrete sounds from the current material.

Gesture: Right palm facing down, hovering above left palm, spread fingers of both hands.

Gravitate

Meaning: Move closer or further away from unison.

Gesture: Right palm facing body, fingers pointing down. Move right hand vertically. Higher is further from unison, lower is closer to unison.

Merge

Meaning: Blend current material into a homogenous texture.

Gesture: Right palm facing body, fingers pointing left.

Synchronize

Meaning: Create an alignment of the current materials.

Gesture: Right palm facing body, fingers pointing left, spread fingers.

Universal Synchrony Music

Appendix: Data Files for Sonifications of Kepler/K2 Area Stars and Planets

Download Files:

https://drive.google.com/open?id=1syMGXK-QY49mmBMZKm9vrMC1967pEb_1

Data Files:

koi_orbiting.csv

kepler1.csv

kepler2.csv

kepler3.csv

kepler47_orbits.rtf

Kep47c-insolation.dat

Kep47d-insolation.dat

Table1_Kepler47d.pdf

Max Patch Files of Doug Van Nort:

sonification_data_coll_read_V2.maxpat

sonification_data_coll_read_V2_noscience.maxpat

sonification_data_text_read_V2.maxpat

sonification_data_text_read_V2_noscience.maxpat

Universal Synchrony Music

By Sarah Rose Weaver

***Conductor Gestures:**

Palette
Cue
Group
Volume Fader
Density Fader
Shapeline-Pulseline
Dimension Point
Pitch Complex Fader
Long Tone
Drone
Gliss
Vibrato
Pulsate
Hits
Pointillism
Resonance
Timbre
Harmonics
Space Complex Fader
Hold
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Multiply
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Merge
Synchronize

Telematic Music Composition for Twelve Performers and Conductor

Locations and Instrumentation

Location 1: In Western Hemisphere

4 instrumentalists (Range: SATB), 1 percussionist (drumset or multiple percussion)

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Location 3: In any geographic location

1 piano, 1 electronics, 1 conductor

Locations perform together live via JackTrip audio conferencing software and Ultragrid video conferencing software on 1Gbps Internet bandwidth (or contemporary equivalent technology). Spatialize audio with 4 or more speakers.

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The score contains palettes of materials including music notation, text notation, graphic notation, gestures, structured improvisations, and sonifications. Perform the palettes in numerical sequence on cue by the conductor. The piece is composed with the expectation of latency between the locations. Perform the materials as written within the latency of the medium.

*All boxed text in the score is detailed in the performance notes.

Approximate Length: 45 minutes

1 Time: 2 Minutes

Electronics: *Sonification 1: Alignment of habitable planets with Earth



2 ♩ = 60

Location 1

Instrument 1: ♩ = 60
2nd Time: Add improvisation duet with Instrument 1 Location 2. Continue playing written material. attention strategy: gravitation

Instrument 2: *mf*

Instrument 3

Instrument 4: *mf*

Perc.: *mf*

Location 2

Instrument 1: *mf*
2nd Time: Add improvisation duet with Instrument 1 Location 1. Continue playing written material. attention strategy: gravitation

Instrument 2: *mf*

Instrument 3: *mf*

Instrument 4: *mf*

Perc.: *mf*

Location 3

Pno.: *mf*

♩ = 60

Electronics (Sonifications)

1st Time: Tacit

2nd Time: *Sonification 2: Light curves of stars from multiplanetary systems with habitable zones

Location 1

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

Location 2

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

Location 3

Pno.

Electronics
(Sonifications)

Location 1

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

Location 2

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

Location 3

Pno.

Electronics (Sonifications)

Location 1

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

Location 2

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

Location 3

Pno.

Electronics
(Sonifications)

3 Time: 1 Minute Piano: Solo utilizing chords from palette 2 and extensions



4 Time: 3 Minutes
Conductor cues each fermata. Materials may overlap.

Location 1

Instrument 1
Instrument 2
Instrument 3
Instrument 4
Perc.

Location 1 musical score for four instruments and percussion. Each instrument part includes a fermata symbol and a callout box: Instrument 1 (*Kepler 62 Light Curve Zoom 2), Instrument 2 (Improvisation duet with Instrument 2 Location 2, attention strategy: gravitation, *Kepler 62 Light Curve Zoom 1), Instrument 3 (*Kepler 62 Light Curve, Improvisation duet with Instrument 3 Location 2, attention strategy: gravitation), and Instrument 4 (*Kepler 69 Phase Curve). Percussion has a single fermata symbol.

Location 2

Instrument 1
Instrument 2
Instrument 3
Instrument 4
Perc.

Location 2 musical score for four instruments and percussion. Each instrument part includes a fermata symbol and a callout box: Instrument 1 (*Kepler 69 Light Curve Zoom 2), Instrument 2 (Improvisation duet with Instrument 2 Location 1, attention strategy: gravitation, *Kepler 69 Light Curve Zoom 1), Instrument 3 (*Kepler 69 Light Curve, Improvisation duet with Instrument 3 Location 1, attention strategy: gravitation), and Instrument 4 (*Kepler 62 Phase Curve). Percussion has a single fermata symbol.

Location 3

Pno.
Electronics (Sonifications)

Location 3 musical score for piano and electronics. The piano part has a fermata symbol. The electronics part has a fermata symbol and a callout box: *Sonification 3: Constellations of stars of multiplanetary habitable systems.

5

Time: 2 Minutes

Instrument 4 Improvisation Duet

Locations 1 & 2: attention strategy: inner universe

Percussionists Improvisation Duet

Locations 1 & 2: attention strategy: search for synchrony



6

$\text{♩} = 108$

Stagger Entrances of Locations, Maintain Tempo Within Location
The full ensemble will not be in the same pulse

Location 1

Instrument 1 f

Instrument 2

Instrument 3 f

Instrument 4 f

Perc. f

Location 2

Instrument 1 f

Instrument 2

Instrument 3 f

Instrument 4 f

Perc. f

Location 3

Pno. f

Electronics (Sonifications)

$\text{♩} = 108$

Location 1

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

Location 2

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

Location 3

Pno.

Electronics
(Sonifications)

Location 1

Musical score for Location 1, measures 1-2. The score consists of five staves: Instrument 1 (Treble clef), Instrument 2 (Treble clef), Instrument 3 (Bass clef), Instrument 4 (Bass clef), and Perc. (Percussion clef).
- **Instrument 1:** Measure 1: *mf* eighth-note triplet. Measure 2: *f* eighth-note triplet.
- **Instrument 2:** Measure 1: Rest. Measure 2: Eighth-note triplet.
- **Instrument 3:** Measure 1: *mf* quarter note. Measure 2: Quarter note with a slur.
- **Instrument 4:** Measure 1: *mf* quarter note. Measure 2: Eighth-note triplet.
- **Perc.:** Measure 1: Eighth-note triplet. Measure 2: Eighth-note triplet.

Location 2

Musical score for Location 2, measures 1-2. The score consists of five staves: Instrument 1 (Treble clef), Instrument 2 (Treble clef), Instrument 3 (Bass clef), Instrument 4 (Bass clef), and Perc. (Percussion clef).
- **Instrument 1:** Measure 1: *mf* eighth-note triplet. Measure 2: *f* eighth-note triplet.
- **Instrument 2:** Measure 1: Rest. Measure 2: Eighth-note triplet.
- **Instrument 3:** Measure 1: *mf* quarter note. Measure 2: Quarter note with a slur.
- **Instrument 4:** Measure 1: *mf* quarter note. Measure 2: Eighth-note triplet.
- **Perc.:** Measure 1: Eighth-note triplet. Measure 2: Eighth-note triplet.

Location 3

Musical score for Location 3, measures 1-2. The score consists of two staves: Pno. (Piano grand staff) and Electronics (Sonifications) (Percussion clef).
- **Pno.:** Measure 1: *mf* eighth-note triplet. Measure 2: *f* eighth-note triplet.
- **Electronics (Sonifications):** Measure 1: Rest. Measure 2: Rest.

Location 1

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

Location 2

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

Location 3

Pno.

Electronics
(Sonifications)

Location 1

Instrument 1 *mf*

Instrument 2

Instrument 3 *f* *mf*

Instrument 4 *f*

Perc. *f*

Location 2

Instrument 1 *mf*

Instrument 2

Instrument 3 *f* *mf*

Instrument 4 *f*

Perc. *f*

Location 3

Pno.

Electronics (Sonifications)

Location 1

Instrument 1 

Instrument 2 

Instrument 3 

Instrument 4 

Perc. 

Location 2

Instrument 1 

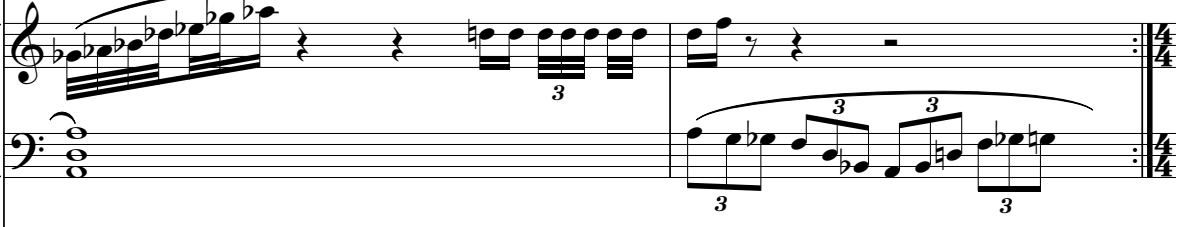
Instrument 2 

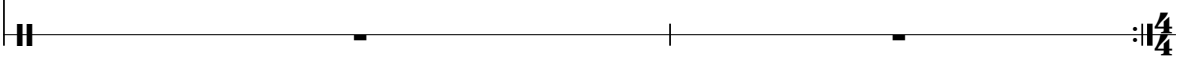
Instrument 3 

Instrument 4 

Perc. 

Location 3

Pno. 

Electronics (Sonifications) 

7

Time: 3 Minutes

All: Improvisation Solos/Duos Layered On Cue

attention strategy: inner habitable zone

Evolve into Group Improvisation

attention strategy: group habitability



8

♩ = 40 Conductor Gives Four Beats Per Measure and Holds Fermata on Beat Four

Location 1

Instrument 1 *mf*

Instrument 2 *mf*

Instrument 3 *mf*

Instrument 4 *mf*

Perc. *p* *mf* *p* *mf*

Location 2

Instrument 1 *mf*

Instrument 2 *mf*

Instrument 3 *mf*

Instrument 4 *mf*

Perc. *mf* *p* *mf* *p*

Location 3

Pno. *mf*

♩ = 40

Electronics (Sonifications)

Improvise with: *Sonification 3: Constellations of stars of multiplanetary habitable systems

9 ♩ = 92 Flexible

Location 1

Instrument 1

mp 1x solo line in trio with cymbals
2x solo improv

Instrument 2

mp 1x tacit, 2x play

Instrument 3

mp 1x tacit, 2x play

Instrument 4

mp 1x tacit, 2x play

Perc.

bowed cymbals, ad. lib.

Location 2

Instrument 1

mp 1x tacit, 2x play

Instrument 2

mp 1x tacit, 2x play

Instrument 3

mp 1x tacit, 2x play

Instrument 4

mp 1x tacit, 2x play

Perc.

bowed cymbals, ad. lib.

Location 3

Pno.

mp 1x tacit, 2x play

Electronics
(Sonifications)

Location 1

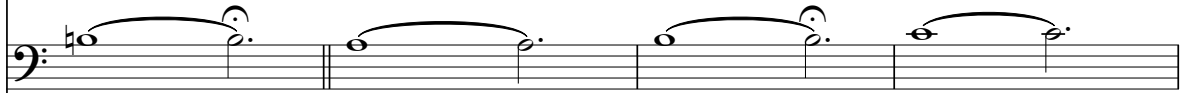
Instrument 1



Instrument 2



Instrument 3

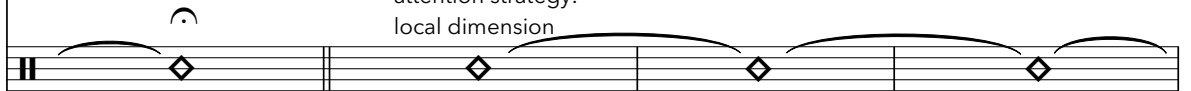


Instrument 4



Perc.

attention strategy:
local dimension



Location 2

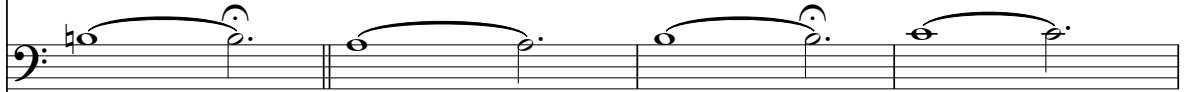
Instrument 1



Instrument 2



Instrument 3

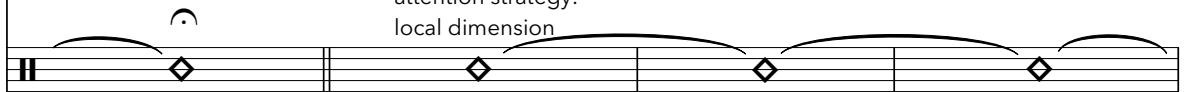


Instrument 4



Perc.

attention strategy:
local dimension



Location 3

Pno.



Electronics
(Sonifications)



Location 1

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

attention strategy:
meta dimension

Location 2

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

attention strategy:
meta dimension

Location 3

Pno.

Electronics
(Sonifications)

Location 1

Instrument 1

Musical notation for Instrument 1 in Location 1. The staff is in treble clef with a key signature of one flat (Bb) and a 5/4 time signature. It features a melodic line with slurs and accents, starting with a quarter note and followed by eighth notes. A dynamic marking of *mf* is present below the staff.

Instrument 2

Musical notation for Instrument 2 in Location 1. The staff is in treble clef with a key signature of one flat (Bb) and a 5/4 time signature. It features a melodic line with slurs and accents, starting with a quarter note and followed by eighth notes. A dynamic marking of *mf* is present below the staff.

Instrument 3

Musical notation for Instrument 3 in Location 1. The staff is in bass clef with a key signature of one flat (Bb) and a 5/4 time signature. It features a melodic line with slurs and accents, starting with a quarter note and followed by eighth notes. A dynamic marking of *mf* is present below the staff.

Instrument 4

Musical notation for Instrument 4 in Location 1. The staff is in bass clef with a key signature of one flat (Bb) and a 5/4 time signature. It features a melodic line with slurs and accents, starting with a quarter note and followed by eighth notes. A dynamic marking of *mf* is present below the staff.

Perc.
attention strategy:
inner dimension

Musical notation for Percussion in Location 1. The staff uses a standard percussion clef and a 5/4 time signature. It features a rhythmic pattern of diamond-shaped symbols with slurs and accents above them.

Location 2

Instrument 1

Musical notation for Instrument 1 in Location 2. The staff is in treble clef with a key signature of one flat (Bb) and a 5/4 time signature. It features a melodic line with slurs and accents, starting with a quarter note and followed by eighth notes. A dynamic marking of *mf* is present below the staff.

Instrument 2

Musical notation for Instrument 2 in Location 2. The staff is in treble clef with a key signature of one flat (Bb) and a 5/4 time signature. It features a melodic line with slurs and accents, starting with a quarter note and followed by eighth notes. A dynamic marking of *mf* is present below the staff.

Instrument 3

Musical notation for Instrument 3 in Location 2. The staff is in bass clef with a key signature of one flat (Bb) and a 5/4 time signature. It features a melodic line with slurs and accents, starting with a quarter note and followed by eighth notes. A dynamic marking of *mf* is present below the staff.

Instrument 4

Musical notation for Instrument 4 in Location 2. The staff is in bass clef with a key signature of one flat (Bb) and a 5/4 time signature. It features a melodic line with slurs and accents, starting with a quarter note and followed by eighth notes. A dynamic marking of *mf* is present below the staff.

Perc.
attention strategy:
inner dimension

Musical notation for Percussion in Location 2. The staff uses a standard percussion clef and a 5/4 time signature. It features a rhythmic pattern of diamond-shaped symbols with slurs and accents above them.

Location 3

Pno.

Musical notation for Piano in Location 3. The piano part is written on a grand staff (treble and bass clefs) with a key signature of one flat (Bb) and a 5/4 time signature. It features a complex texture with slurs and accents. A dynamic marking of *mf* is present below the bass staff.

Electronics
(Sonifications)

Musical notation for Electronics (Sonifications) in Location 3. The staff uses a standard percussion clef and a 5/4 time signature. It features a rhythmic pattern of diamond-shaped symbols with slurs and accents above them.

10

Time: 1 Minute

Percussion: Improvisation duet
attention strategy: search for synchrony



11

Time: 2 Minutes

Electronics:

*Sonification 4: Kepler 47
Habitable Binary Star System



Location 1

12 ♩ = 80

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

Location 2

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

Location 3

Pno.

Electronics
(Sonifications)

Continue: *Sonification 4: Kepler 47
Habitable Binary Star System

Location 1

Instrument 1 harmonics/multiphonics add extensions return to written pitch
mf mp

Instrument 2 harmonics/multiphonics add extensions return to written pitch
mf mp

Instrument 3 harmonics/multiphonics add extensions return to written pitch
mf mp

Instrument 4

Perc. cymbal 1 cymbal 2
mp mf mp

Location 2

Instrument 1 harmonics/multiphonics add extensions return to written pitch
mf mp

Instrument 2 harmonics/multiphonics add extensions return to written pitch
mf mp

Instrument 3 harmonics/multiphonics return to extensions written pitches *sim.*

Instrument 4 harmonics/multiphonics return to extensions written pitches *sim.*

Perc. *sim.*

Location 3

Pno. *p < mp > p*

Electronics (Sonifications)

Location 1

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

harmonics/
multiphonics

add extensions

return to written pitch

mp *mf* *mp*

harmonics/
multiphonics

add extensions

return to written pitch

mp *mf* *mp*

harmonics/
multiphonics

add extensions

return to written pitch

mp *mf* *mp*

Instrument 4

Perc.

mp *mf* *mp*

Location 2

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

harmonics/
multiphonics

add extensions

return to written pitch

mp *mf* *mp*

harmonics/
multiphonics

add extensions

return to written pitch

mp *mf* *mp*

Instrument 3

Instrument 4

Perc.

mp *mf* *mp*

Location 3

Pno.

Electronics
(Sonifications)

Pno.

Electronics
(Sonifications)

Location 1

Musical score for Location 1, measures 1-5. The score includes five staves: Instrument 1 (Treble clef), Instrument 2 (Treble clef), Instrument 3 (Bass clef), Instrument 4 (Bass clef), and Perc. (Percussion).
- Instrument 1: Rests in measures 1-3. In measure 4, a half note G4 is marked with *tr* and *mp*. In measure 5, a half note A4 is marked with *tr* and *mp*.
- Instrument 2: Rests in measures 1-4. In measure 5, a half note G4 is marked with *tr* and *mp*.
- Instrument 3: Rests in measures 1-4. In measure 5, a half note G2 is marked with *mp*.
- Instrument 4: Five diamond-shaped symbols (sonifications) on the staff line.
- Perc.: Rests in all five measures.

Location 2

Musical score for Location 2, measures 1-5. The score includes five staves: Instrument 1 (Treble clef), Instrument 2 (Treble clef), Instrument 3 (Bass clef), Instrument 4 (Bass clef), and Perc. (Percussion).
- Instrument 1: Rests in measures 1-4. In measure 5, a half note G4 is marked with *tr* and *mp*.
- Instrument 2: Rests in measures 1-4. In measure 5, a half note G4 is marked with *tr* and *mp*.
- Instrument 3: Active melody in bass clef, starting with a half note G2 in measure 1 and ending with a half note G2 in measure 5.
- Instrument 4: Active melody in bass clef, starting with a half note G2 in measure 1 and ending with a half note G2 in measure 5.
- Perc.: Active melody in percussion clef, starting with a half note G4 in measure 1 and ending with a half note G4 in measure 5.

Location 3

Musical score for Location 3, measures 1-5. The score includes two staves: Pno. (Piano) and Electronics (Sonifications).
- Pno.: Grand staff (Treble and Bass clefs) with rests in all five measures.
- Electronics (Sonifications): Five diamond-shaped symbols on the staff line.

Location 1

Instrument 1
add extensions
return to written pitch
mf *mp*
tr
mp

Instrument 2
add extensions
return to written pitch
mf *mp*

Instrument 3
add extensions
harmonics/
multiphonics
return to written pitch
mf *mp*

Instrument 4
◇ ◇ ◇ ◇ ◇

Perc.
mp *mf* *mp*

Location 2

Instrument 1
add extensions
return to written pitch
mf *mp*

Instrument 2
add extensions
return to written pitch
mf *mp*

Instrument 3
Instrument 4

Perc.
#

Location 3

Pno.

Electronics
(Sonifications)
◇ ◇ ◇ ◇ ◇

Location 1

Instrument 1
Instrument 2
Instrument 3
Instrument 4
Perc.

Musical score for Location 1. It features five staves: Instrument 1 (treble clef), Instrument 2 (treble clef), Instrument 3 (bass clef), Instrument 4 (bass clef), and Percussion (percussion clef). Instrument 1 and 2 have a melodic line with a trill (tr) at the start, followed by a phrase with dynamics *mp*, *mf*, and *mp*. Annotations include "add extensions" and "return to written pitch". Instrument 3 has a similar melodic line with dynamics *mp*, *mf*, and *mp*, and an annotation "harmonics/multiphonics". Instrument 4 has a rhythmic pattern of diamond-shaped notes. Percussion has a rhythmic pattern with dynamics *mp*, *mf*, and *mp*.

Location 2

Instrument 1
Instrument 2
Instrument 3
Instrument 4
Perc.

Musical score for Location 2. It features five staves: Instrument 1 (treble clef), Instrument 2 (treble clef), Instrument 3 (bass clef), Instrument 4 (bass clef), and Percussion (percussion clef). Instrument 1 and 2 have a melodic line with a trill (tr) at the start, followed by a phrase with dynamics *mp*, *mf*, and *mp*. Annotations include "add extensions" and "return to written pitch". Instrument 3 and 4 have a complex melodic line with many accidentals. Percussion has a complex rhythmic pattern with dynamics *mp*, *mf*, and *mp*.

Location 3

Pno.
Electronics (Sonifications)

Musical score for Location 3. It features two staves: Piano (Pno.) and Electronics (Sonifications). The Piano staff has a complex melodic line with many accidentals. The Electronics staff has a rhythmic pattern of diamond-shaped notes.

13

Time: 3 Minutes All: On cue, improvise with Palette 12 materials.

attention strategy: habitable zone

Electronics: Record Musicians and Play them back within Sonification 4 timing



14

♩ = 40 Flexible

Play written line independently for layered ensemble texture

Location 1

Instrument 1 *p*

Instrument 2 *p*

Instrument 3 *p*

Instrument 4 *p*

Perc. *mf* *sim.*

Detailed description: This block contains the musical notation for Location 1. It features five staves: Instrument 1 (treble clef), Instrument 2 (treble clef), Instrument 3 (bass clef), Instrument 4 (bass clef), and Percussion (percussion clef). The notation includes various note values, rests, and dynamic markings such as *p* and *mf*. There are also performance instructions like *sim.* and *p < mp > p* with a 4-measure rest symbol above the notes.

Location 2

Instrument 1 *p*

Instrument 2 *p*

Instrument 3 *p*

Instrument 4 *p*

Perc. *mf* *sim.*

Detailed description: This block contains the musical notation for Location 2, which is identical in notation to Location 1. It features five staves: Instrument 1 (treble clef), Instrument 2 (treble clef), Instrument 3 (bass clef), Instrument 4 (bass clef), and Percussion (percussion clef). The notation includes various note values, rests, and dynamic markings such as *p* and *mf*. There are also performance instructions like *sim.* and *p < mp > p* with a 4-measure rest symbol above the notes.

Location 3

Pno. *p < mp > p*

Electronics (Sonifications) ♩ = 40 Flexible

Detailed description: This block contains the musical notation for Location 3. It features two staves: Piano (grand staff) and Electronics (Sonifications). The Piano part includes a 4-measure rest symbol with *p < mp > p* above it. The Electronics part includes a tempo marking of ♩ = 40 Flexible and a diamond-shaped symbol.

Improvisation with Sonification 4
attention strategy: synchrony

Location 1

Instrument 1

Musical staff for Instrument 1 in Location 1. The staff is in treble clef and contains a melodic line with a half note, a quarter note, and a half note, followed by a long rest. A slur covers the next three notes: a quarter note, a quarter note, and a quarter note. A fourth finger fingering (4) is indicated above the first note of the slur. The staff ends with a half note and a quarter note.

Instrument 2

Musical staff for Instrument 2 in Location 1. The staff is in treble clef and contains a melodic line with a half note, a quarter note, and a half note, followed by a long rest. A slur covers the next three notes: a quarter note, a quarter note, and a quarter note. A fourth finger fingering (4) is indicated above the first note of the slur. The staff ends with a half note and a quarter note.

Instrument 3

Musical staff for Instrument 3 in Location 1. The staff is in bass clef and contains a melodic line with a half note, a quarter note, and a half note, followed by a long rest. A slur covers the next three notes: a quarter note, a quarter note, and a quarter note. A fourth finger fingering (4) is indicated above the first note of the slur. The staff ends with a half note and a quarter note.

Instrument 4

Musical staff for Instrument 4 in Location 1. The staff is in bass clef and contains a melodic line with a half note, a quarter note, and a half note, followed by a long rest. A slur covers the next three notes: a quarter note, a quarter note, and a quarter note. A fourth finger fingering (4) is indicated above the first note of the slur. The staff ends with a half note and a quarter note.

Perc.

Musical staff for Percussion in Location 1. The staff is in common time and contains a rhythmic pattern of eighth notes and quarter notes, with some notes beamed together. There are vertical tick marks below the staff indicating specific rhythmic events.

Location 2

Instrument 1

Musical staff for Instrument 1 in Location 2. The staff is in treble clef and contains a melodic line with a half note, a quarter note, and a half note, followed by a long rest. A slur covers the next three notes: a quarter note, a quarter note, and a quarter note. A fourth finger fingering (4) is indicated above the first note of the slur. The staff ends with a half note and a quarter note.

Instrument 2

Musical staff for Instrument 2 in Location 2. The staff is in treble clef and contains a melodic line with a half note, a quarter note, and a half note, followed by a long rest. A slur covers the next three notes: a quarter note, a quarter note, and a quarter note. A fourth finger fingering (4) is indicated above the first note of the slur. The staff ends with a half note and a quarter note.

Instrument 3

Musical staff for Instrument 3 in Location 2. The staff is in bass clef and contains a melodic line with a half note, a quarter note, and a half note, followed by a long rest. A slur covers the next three notes: a quarter note, a quarter note, and a quarter note. A fourth finger fingering (4) is indicated above the first note of the slur. The staff ends with a half note and a quarter note.

Instrument 4

Musical staff for Instrument 4 in Location 2. The staff is in bass clef and contains a melodic line with a half note, a quarter note, and a half note, followed by a long rest. A slur covers the next three notes: a quarter note, a quarter note, and a quarter note. A fourth finger fingering (4) is indicated above the first note of the slur. The staff ends with a half note and a quarter note.

Perc.

Musical staff for Percussion in Location 2. The staff is in common time and contains a rhythmic pattern of eighth notes and quarter notes, with some notes beamed together. There are vertical tick marks below the staff indicating specific rhythmic events.

Location 3

Pno.

Musical staff for Piano in Location 3. The staff is in grand staff (treble and bass clefs) and contains a chordal accompaniment. The left hand plays a bass line with a half note and a quarter note, while the right hand plays a chordal accompaniment with a half note and a quarter note.

Electronics
(Sonifications)

Musical staff for Electronics in Location 3. The staff is in common time and contains a single diamond-shaped symbol in the middle of the staff, indicating a specific electronic event.

Location 1

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

Location 2

Instrument 1

Instrument 2

Instrument 3

Instrument 4

Perc.

Location 3

Pno.

Electronics (Sonifications)



15

Time: 3 Minutes
 All: Improvise with materials from Palette 14.
 attention strategy: synchrony

FIN